MINUTES AND PROCEEDINGS

of the

# ARMY-NAVY-O S R D

# VISION COMMITTEE

FIFTH MEETING - 16 SEPTEMBER 1944



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# M I N U T E S   A N D   P R O C E E D I N G S

of the fifth meeting of the

ARMY - NAVY - OSRD VISION COMMITTEE

September 16, 1944

The Tiffany Foundation
Oyster Bay, Long Island, New York

~~CONFIDENTIAL~~

U. S. Armed Forces - NRC Vision Committee

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ARMY - NAVY - OSRD VISION COMMITTEE

MINUTES

Fifth Meeting
The Tiffany Foundation
1030, 16 September 1944

The following were present:

| | | |
|---|---|---|
| ARMY | AAF | (M)Dr. D. W. Bronk |
| | | Lt. A. Chapanis, Aero Medical Laboratory, Wright Field |
| | | Capt. George A. Levi, Arctic, Desert, and Tropic Information Center |
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| | Engrs | (M)Major S. K. Guth |
| | | Dr. George E. Wald, Consultant, Engineer Board |
| | Ord | (A)Mr. John E. Darr |
| | | Dr. William S. Carlson, Fire Control Laboratory, Frankford Arsenal |
| | QMG | (A)Capt. Richard M. Toucey |
| | SG | (M)Lt. Col. W. L. Cook, Jr. |
| | WDLO | (M)Capt. Howard E. Clements |
| | | Major H. E. Noble, Liaison Officer with NDRC |
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| | BuAer | (A)Lt. Harry London |
| | | (CM)Lt. Comdr. David Leavitt |
| | | Lt. Comdr. R. K. West, Engineering Division |
| | BuMed | (A)Lt. Comdr. R. H. Peckham |
| | | (CM)Dr. Harold F. Blum |
| | | Lt. Comdr. R. H. Lee, Naval Medical Research Institute |
| | | Lt. (jg) Harry Older, Aviation Psychology Section |
| | | Ens. Sherman Ross, Medical Field Research Laboratory, Camp Lejeune |
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| | I C Bd | (M)Lt. George W. Dyson |
| | NRL | (A)Dr. Richard Tousey |
| | SONRD | (M)Lt. Comdr. H. Gordon Dyke |
| | SubBase | (M)Capt. C. W. Shilling |
| | | Lt. Dean Farnsworth, Medical Research Laboratory |

| | | |
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| NAVY | ATC | Lt. R. E. Blackwell, Amphibious Training Command, Norfolk |
| | | Lt. John H. Sulzman, Amphibious Training Command, Norfolk |
| | NO | Lt. (jg) Frederick Ottie, Naval Observatory |
| OSRD | NDRC | (M)Dr. Theodore Dunham |
| | | (M)Dr. A. C. Hardy |
| | | (M)Dr. Brian O'Brien |
| | | Dr. Howard S. Coleman, Division 16, Pennsylvania State College |
| | | Dr. S. Q. Duntley, Technical Aide, Section 16.3, M.I.T. |
| | | Miss Lillian Elvebach, Technical Aide, Section 16.1, M.I.T. |
| | | Dr. Sidney McCuskey, Technical Aide, Section 16.1, M.I.T. |
| | APP | (M)Dr. H. K. Hartline |
| | | Dr. W. C. H. Prentice, Project N-115, Princeton |
| | | Dr. Carl H. Wedell, Project N-115, Princeton |
| | | Dr. Dael Wolfle, Technical Aide |
| | CMR | (M)Dr. Walter Miles |
| | NRC | (CM)Dr. Selig Hecht |
| | OSRD | (M)Dr. Donald G. Marquis |

Mr. C. A. Douglas, National Bureau of Standards
Mr. Lewis P. Harrison, Weather Bureau
Squadron Leader E. A. G. Goldie, RAF Delegation

1. The following correction should be made in the Proceedings of the fourth meeting: On p. 27, line 21, insert "by an artist" after "had been designed."

2. On arrival at the Tiffany Foundation, members and guests were divided into groups of approximately six each and taken on a tour of the Foundation. Each of the projects dealing with visibility or with atmospheric optics was visited.

3. Captain R. M. Toucey reported a proposed standardized sun- 9*
glass design (Minutes, fourth meeting, p. 7, item 6) to be procured in quantity by QMG for the Army Ground Forces. A sample was submitted for examination.

4. Lt. Comdr. R. H. Peckham, representing the Subcommittee on 12
Sun-scanning Goggles, presented further information on the transmission of solar radiation by glass and plastic used in sunglasses.

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*Numbers at the right refer to pages in the Proceedings on which the full report or discussion is presented.

5. The major discussion of the afternoon included the presentation of results obtained in the Tiffany research program on factors influencing visibility and comments from representatives of the services on military problems of visibility.

A. Dr. Hardy described the various projects at the Foundation, discussed some of the results, and indicated certain service problems that can be solved by such data. Dr. Duntley discussed the effect of atmospheric scattering of light on visibility. 29

B. Lt. Comdr. Leavitt emphasized the importance of visibility information to the problems of aircraft camouflage and air-sea rescue search. 33

C. Comdr. Bittinger explained some of the difficulties involved in successful ship camouflage and listed several approaches to the problem: (1) make the ship invisible; (2) destroy the contour; and (3) destroy the identity (class).

D. Col. Sanger, who was unable to remain for the discussion, provided a list of visibility problems confronting the Army Ground Forces for inclusion in the Proceedings. 36

6. A new model 6x42 plastic combat binocular, developed by the U. S. Naval Observatory, was submitted to the Committee for examination and comment by Lt. (jg) Ottie, who described the instrument and explained its uses. 37

ARMY - NAVY - OSRD VISION COMMITTEE

PROCEEDINGS

Fifth Meeting
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## 3. PROPOSED STANDARDIZED SUNGLASS DESIGN

The following report was prepared and presented by Capt. Toucey.

The question of specifying sunglasses of standardized design and quality for use by Army Ground Force personnel is a difficult one because of the background of widely varying commercial practices and the paucity of technical information on the following pertinent points:

a) What are the minimum optical standards for sunglass lenses?
b) What is the optimal total transmission in visible? ultraviolet? infrared?
c) What is the optimal color for lenses?
d) Are polarizing lenses preferable, acceptable, or undesirable?
e) How important is the reduction of rear reflection?

These questions should be answerable by medical science. However, at the present date they have not been attacked rigorously nor studied with the ultimate purpose of compiling sufficient data to set down a calculated answer. These questions were submitted to this committee, at the last meeting, for information upon which to base a decision.

In addition there is the problem of construction of the sunglass to provide strength, durability, compactness, adequate field of vision, and a secure and comfortable fit. These are all points which must be answered by the Military after an analysis of the conditions under which the sunglasses may be expected to be used.

A further consideration which always governs the supply of military equipment is the availability of manufacturing facilities for producing the quantity of items which must be supplied.

All of these problems must govern the specification of a standardized sunglass. After careful review of the information

available, the following requirements for a standardized sunglass have been established:

a) Minimum Optical Standards

(1) Focal Power - There shall not be more than 1/16 diopter of power in any meridian and the difference in power between any two meridians shall not exceed 1/16 diopter.

(2) Prismatic Power - The prismatic effect shall not exceed 1/8 diopter.

(3) Definition - The lenses when placed in front of a 6 power telescope of 10 mm. aperture (able to resolve 15 seconds or better) shall permit the resolution of 15 seconds of arc.

b) Color of Lenses - The color of the lenses shall be substantially neutral so as not to distort markedly the color perception of the wearer.

c) Transmission of Lenses - The lenses shall transmit not more than 15 percent nor less than 10 percent of visible radiation.

d) Polarization - The lenses shall be polarizing to reduce glare reflection from horizontal surfaces.

e) Rear Reflection - The lens shall be curved or formed to a face form fit to reduce rear reflection to a minimum.

Taking these specifications into consideration and, in addition, a sunglass construction that is acceptable from the standpoint of strength, durability, compactness, field of vision, and secure and comfortable fit, the Brow-Rest Sunglass has been selected as the most practical design that can be produced in the required quantities.

This sunglass embodies the following features in its construction: a plastic frame consisting of a bar type channelled member, designed to hold the top of a sheet plastic lens, which extends downward to cover the eyes of the wearer; a bridge piece with integral nose pads, attached to the center of the lens in a manner which supports the lens in the proper position before the eyes of the wearer; comfort cable type, metal cored, plastic covered temples, which are adjustable to various head sizes; and three barrel combination metal and plastic hinges, the metal portion of which is welded to the metal core of the temple pieces.

It is pointed out that one objectionable feature of the

sunglass selected is the fact that the plastic lens is susceptible to scratching. On the other hand, glass lenses are breakable. Breakage not only renders the sunglass useless, but it is a source of potential damage to the wearer's eyes.

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Discussion:

In response to a question from Lt. Chapanis, Capt. Toucey stated that the specifications for the standardized design are acceptable to manufacturers.

Squadron Leader Goldie pointed out that British experience has emphasized the danger to visibility of scratched plastic, and for this reason the use of glass is preferred. He asked whether or not any specifications regarding scratching of plastic surface had been formulated. Capt. Toucey said that there were no such specifications, but that the breakage involved in the use of glass is considered a greater disadvantage than the scratching of plastic.

Lt. Comdr. Dyke called attention to the development by NDRC of new plastic lenses. QMG had investigated this development.

Lt. Chapanis inquired about the choice of 1/8 prism diopter as the maximum tolerance. The reasons for the selection were that such a standard is acceptable in use and is commercially feasible. Other members supported this by pointing out that visual tolerance to 1/8 D is common, that it makes little difference in seeing. As a matter of fact, it is impossible for as much as 1/8 D to occur in plastic as thin as that being used.

Specifications for infrared transmission have not been considered necessary in a glass with a transmission of visible light as great as 10 percent.

## 4. SOLAR TRANSMISSION OF GLASS AND PLASTIC USED IN SUNGLASSES

The following report was prepared by Lt. Comdr. Peckham

### I. General Procedure

The curve of solar radiation found in the VIIIth edition of the Smithsonian Tables, Air Mass zero, has been used as the basis for computing effective solar transmission of various filters. This curve has been reduced to such relative units that the summation at 50 millimicron intervals equals a multiple of 10, for convenience in computation of relative transmission. This curve is shown in Table One, and again in Figure Three. It will be noted that solar radiation has been used without correction for absorption by water vapor or dust particles and is, therefore, applicable to any altitude. When used for sea-level estimation, the omission of these absorptions will yield a conservative safety factor.

The computation of solar energy starts at 250 millimicrons and has been stopped at 2200 millimicrons. At this latter point the curve becomes nearly asymptotic to zero.

The transmission of the ocular media has been deduced from Dr. H. F. Blum's report to the second meeting of this Committee. These transmissions are shown in Table One, and the transmission of solar energy to the retina is shown in Figure Four. The computation of solar energy transmitted for a given filter is accomplished by entering the transmission of the filter for the designated wavelengths in the column marked "$F_n$" in the form used for Table One, multiplying these transmissions by the solar energy and entering them in the column marked "Energy at the Cornea", summating these values and dividing by 10, to yield the transmission integral in percentage. The relative energy values found at the cornea are multiplied by the transmission of the ocular media, entered as "Energy at Retina", summated and divided by 10 to yield the percentage of energy at the retina.

Computation of ultraviolet depends upon the product of the curves of erythemal effectiveness of ultraviolet light, multiplied by the estimate of solar energy in the ultraviolet, to yield a curve of erythemal effectiveness of solar ultraviolet radiation, as shown in Figure One. This curve extends from 295 to 320 millimicrons. It has been divided into three equal areas, and the centers of gravity of these areas have been chosen at 302, 306, and 311 millimicrons. The transmissions of the filters studied are averaged for these wavelengths to determine the erythemal effectiveness of the filters as shown in Table Two.

Computation of the visual brightness and color is accomplished by the form shown in Table Three, which is based

upon the International Committee on Illuminants as published in Hardy's Handbook of Colorimetry. The computation is done at ten millimicron intervals. The $\bar{y}$ factors have been reduced to summate to a multiple of ten and the other factors are changed proportionately. This computation permits estimate of the brightness of the filter with respect to the visual sensitivity curve as well as the determination of the color coordinates of the filter. The standard illuminant "C" is used since the filters are to be used in sunlight.

The spectrogram for this computation of filters requires estimates from 250 to 350 at 50 millimicron intervals, from 380 to 730 at 10 millimicron intervals, and from 750 to 2200 at 50 millimicron intervals. In addition, if there is any transmission between 250 and 350 millimicrons, the transmissions at 302, 306, and 311 must be determined.

## II. Sunglasses

Three typical sunglass lenses have been studied completely, and two partially, for this report. These are the glass Calobar "C" (American Optical Company), and the plastics XN30 and HN12 (Polaroid Corporation). The glass Calobar "D" and the plastic XN10 have been computed for the visual range only. The glass Calobar "C" is used for aviator's goggles, type AN6530. The plastic XN30 is non-polarizing, and is proposed for use in the sun-scanning device. The plastic HN12 is polarizing and is used in the Brow-Rest type sun glass, Navy Specification 37G-INT. A theoretical green gelatine filter called TGm is presented for comparison only. (The computations for "Rose-Smoke" and "Rayban" glass will be presented as an addendum to the next Vision Committee meeting report.)

Spectrograms of the first three of these materials are shown in Figure Two. In the ultraviolet, only the material XN30 transmits energy in the erythemal region. In the visual range, Calobar "C" shows a peak at 540, HN12 at 500, and XN30 a steady rise past red at 730. In the infrared region, Calobar "C" shows a strong absorption until 1200, and thereafter, a rise to a peak at 2300 with a gradual decrease to over 4000. XN30 shows a plateau of high infrared transmission from 1100 to 2000, and HN12 shows a peak of 90% transmission at 1200 in the infrared. Both plastic filters show the strong acetate absorption bands near 2500. This figure illustrates the misleading effect of specification of overall infrared, or of short selected bands in the infrared. For example, the loose application of the term infrared could be construed to mean 90% infrared transmission for a plastic filter and 8% infrared transmission for a glass filter, but this is true only near 1200. On the other hand, the glass transmits nearly 40%, while the plastic transmits less than 5%, in the infrared, but only at 2500. Total energy estimates are also misleading since the plastic beyond 2500 is a high transmitter and the total energy estimate will therefore average in high values to an estimate which is actually beyond the limit of solar radiation. On the other hand,

the glass value so obtained averages in a long section of nearly zero transmissions. This concept of total energy specification is particularly midleading when it is recalled that the energy source, Tungsten light, is nearly inverse with respect to sunlight because of its high infrared emission.

A more applicable statement of the effective transmission of sun-glass lenses is the computation of these glasses against the solar radiation curve. This computation results in the curves shown in Figure Three. The solid line represents the trace of the solar radiation. The high transmission of the plastics for infrared is shown to be less startling by this method. Since the solar radiation is itself low at 1000, the peak transmission of the plastic HN12 is reduced to a moderate residual flow of energy gradually diminishing as the wavelength increases.

The effect of the ocular media is to absorb still further the infrared energy. As shown in Figure Four, the action of the ocular media is to reduce all three filters to nearly the same energy total. Actually, because of its high transmission from 500 to 600, the glass filter gives the greatest heating effect of the three materials here studied.

As can be seen in Table Two, only the XN30 filter transmits appreciable ultraviolet, and its erythemal effectiveness is estimated at three tenths of one percent, which is a negligible amount. Neither the lenses in the aviation flying goggle nor those in the sun glasses the Navy is procuring transmit erythemal ultraviolet energy.

The color and brightness of these sunglass lenses are of considerable importance. The glass lenses do not reduce the light for an amount great enough to satisfy the recommendations of this committee. The visual effectiveness of Calobar "C" is 53%. The effectiveness of XN30 plastic is 31%. The effectiveness of the sample HN12, measured for this report, is 18%. Since this sample was made, the dye concentration of this material has been increased so that it will be 12% visually effective. This change does not otherwise affect the conclusions here presented.

In addition, two other lenses, Calobar "D" and XN10 have been studied in the visual range only. Calobar "D" is 38% visually effective. XN10, a non-polarizing plastic lens, is 8% visually effective. A theoretical green filter TGm, which satisfies one specification for "neutral" is also presented for color study only.

The colors of these filters have been computed on the ICI system. These are shown in Table Four.

Each of these lenses lies near the trace of Munsell color samples of brightness 5, saturation 2. Such a trace is a logical basis for definition of "neutral" since it is extremely difficult to

prepare and reproduce absolutely neutral filters. The positions of five Munsell colors, R(ed), Y(ellow), G(reen), B(lue) and P(urple), as well as the positions of the five neutral lenses here described, are shown in Figure Five.

The effect of such colored neutral lenses on samples of weak saturation is an excellent demonstration of the effect of these almost neutral filters on the natural desaturation of colored objects in nature. In each case, the shifting of the trace is approximately equivalent to the shift of the lens itself from the point of Illuminant "C" on the ICI chart. These shifts are shown in Figure Six.

Table Five shows the changes of the colors through the lenses here reported. In each case the complement of the color of the filter approaches the original neutral area, and is lost to color perception. It follows, therefore, that every effort should be made to establish the neutrality of sunglass lenses.

## Summary

The computations made for this report are summarized in Table Six. Ultraviolet transmission is negligible for the three lenses examined. Total energy or heating effect is not greatly different for the glass or the plastic lenses. The color of the lenses would indicate that Calobar "C" and the plastic lenses are all about equally colored and are all acceptable.

## Conclusions

1. Ultraviolet protection is adequate in the lenses proposed for sunglasses.
2. Total energy (heat) protection is adequate in the lenses proposed for sunglasses.
3. Calobar "C" and Calobar "D" and XN30 are too bright to be recommended for sun glasses except for aviation use.
4. Calobar "D" is too green to be defined as "essentially neutral".
5. The necessary computations for the selection of "neutral" sunglass lenses require adequate spectrographic measurements. Short-cut methods of overall transmission are misleading and are not recommended.

TABLE I

Total Energy Computation of Glass - "Calobar C"

| mmu | Relative Intensity | $F_n$ | Energy at Cornea | Ocular Media | Energy at Retina |
|---|---|---|---|---|---|
| 250 | 0 | 0 | 0 | 0.0 | 0 |
| 300 | 0 | 0 | 0 | .0 | 0 |
| 350 | 40 | 0 | 0 | .025 | 0 |
| 400 | 62 | 0.23 | 14.26 | .100 | 1.43 |
| 450 | 93 | 0.40 | 37.20 | .408 | 15.18 |
| 500 | 92 | 0.54 | 49.68 | .500 | 24.84 |
| 550 | 85 | 0.56 | 47.60 | .567 | 26.99 |
| 600 | 76 | 0.51 | 38.76 | .614 | 23.80 |
| 650 | 63 | 0.41 | 25.83 | .667 | 17.23 |
| 700 | 55 | 0.28 | 15.40 | .712 | 10.97 |
| 750 | 46 | 0.17 | 7.82 | .709 | 5.54 |
| 800 | 40 | 0.16 | 6.40 | .720 | 4.61 |
| 850 | 35 | 0.15 | 5.25 | .722 | 3.79 |
| 900 | 31 | 0.13 | 4.03 | .618 | 2.49 |
| 950 | 29 | 0.12 | 3.48 | .480 | 1.67 |
| 1000 | 25 | 0.10 | 2.50 | .364 | 0.91 |
| 1050 | 22 | 0.10 | 2.20 | .300 | 0.66 |
| 1100 | 21 | 0.09 | 1.99 | .246 | 0.49 |
| 1150 | 19 | 0.09 | 1.71 | .160 | 0.27 |
| 1200 | 17 | 0.09 | 1.53 | .109 | 0.17 |
| 1250 | 15 | 0.09 | 1.35 | .072 | 0.10 |
| 1300 | 14 | 0.11 | 1.54 | .0 | 0 |
| 1350 | 13 | 0.13 | 1.69 | | |
| 1400 | 11 | 0.14 | 1.54 | | |
| 1450 | 10 | 0.17 | 1.70 | | |
| 1500 | 9 | 0.20 | 1.80 | | |
| 1550 | 9 | 0.22 | 1.98 | | |
| 1600 | 8 | 0.24 | 1.92 | | |
| 1650 | 8 | 0.26 | 2.08 | | |
| 1700 | 7 | 0.28 | 1.96 | | |
| 1750 | 6 | 0.29 | 1.74 | | |
| 1800 | 6 | 0.30 | 1.80 | | |
| 1850 | 6 | 0.31 | 1.86 | | |
| 1900 | 5 | 0.31 | 1.55 | | |
| 1950 | 5 | 0.32 | 1.60 | | |
| 2000 | 4 | 0.32 | 1.28 | | |
| 2050 | 4 | 0.33 | 1.32 | | |
| 2100 | 3 | 0.34 | 1.02 | | |
| 2150 | 3 | 0.35 | 1.05 | | |
| 2200 | 3 | 0.36 | 1.08 | | |
| TOTAL | 1,000 | | 297.50 | | 141.14 |

Percent trans. at cornea <u>29.75</u> Percent trans. at retina <u>14.1</u>

TABLE II

Erythemal Effectiveness of XN30

| mmu | F |
|---|---|
| 302 | 0 |
| 306 | 0.003 |
| 311 | 0.006 |
| TOTAL | 0.009 |
| Average | 0.003 |

Erythemal Effectiveness = 0.3%

TABLE III

Visual Brightness and Color of "Calobar C"

| mmu | $F_n$ | $\bar{y}$ | | $\bar{x}$ | | $\bar{z}$ | |
|---|---|---|---|---|---|---|---|
| 380 | 0.09 | .000 | 0 | .000 | 0 | .002 | 0 |
| 390 | 0.19 | .000 | 0 | .002 | 0 | .009 | 0.002 |
| 400 | 0.23 | .000 | 0 | .009 | 0.002 | .040 | 0.009 |
| 410 | 0.26 | .001 | 0 | .033 | 0.009 | .157 | 0.041 |
| 420 | 0.30 | .004 | 0.001 | .124 | 0.037 | .595 | 0.179 |
| 430 | 0.33 | .012 | 0.004 | .300 | 0.099 | 1.463 | 0.483 |
| 440 | 0.36 | .026 | 0.009 | .397 | 0.143 | 1.993 | 0.717 |
| 450 | 0.40 | .044 | 0.018 | .392 | 0.157 | 2.064 | 0.826 |
| 460 | 0.45 | .070 | 0.032 | .336 | 0.151 | 1.930 | 0.869 |
| 470 | 0.48 | .106 | 0.051 | .227 | 0.109 | 1.497 | 0.719 |
| 480 | 0.51 | .162 | 0.083 | .111 | 0.057 | .946 | 0.482 |
| 490 | 0.52 | .236 | 0.123 | .036 | 0.019 | .527 | 0.274 |
| 500 | 0.54 | .340 | 0.184 | .005 | 0.003 | .286 | 0.154 |
| 510 | 0.55 | .483 | 0.266 | .009 | 0.005 | .152 | 0.084 |
| 520 | 0.56 | .646 | 0.362 | .058 | 0.032 | .071 | 0.040 |
| 530 | 0.56 | .794 | 0.445 | .152 | 0.085 | .039 | 0.022 |
| 540 | 0.57 | .915 | 0.522 | .279 | 0.159 | .020 | 0.011 |
| 550 | 0.56 | .983 | 0.550 | .428 | 0.240 | .009 | 0.005 |
| 560 | 0.56 | .984 | 0.551 | .588 | 0.329 | .004 | 0.002 |
| 570 | 0.55 | .915 | 0.503 | .732 | 0.403 | .002 | 0.001 |
| 580 | 0.54 | .799 | 0.431 | .842 | 0.455 | .002 | 0.001 |
| 590 | 0.52 | .663 | 0.345 | .898 | 0.467 | .001 | 0 |
| 600 | 0.51 | .532 | 0.271 | .895 | 0.456 | .001 | 0 |
| 610 | 0.49 | .418 | 0.205 | .833 | 0.408 | | |
| 620 | 0.47 | .315 | 0.148 | .707 | 0.332 | | |
| 630 | 0.45 | .219 | 0.099 | .531 | 0.239 | | |
| 640 | 0.43 | .144 | 0.062 | .369 | 0.159 | | |
| 650 | 0.41 | .089 | 0.036 | .233 | 0.096 | | |
| 660 | 0.38 | .050 | 0.019 | .136 | 0.052 | | |
| 670 | 0.36 | .026 | 0.009 | .071 | 0.026 | | |
| 680 | 0.34 | .013 | 0.004 | .037 | 0.013 | | |
| 690 | 0.31 | .006 | 0.002 | .017 | 0.005 | | |
| 700 | 0.28 | .003 | 0.001 | .008 | 0.002 | | |
| 710 | 0.26 | .001 | 0 | .004 | 0.001 | | |
| 720 | 0.23 | .001 | 0 | .002 | 0 | | |
| 730 | 0.21 | .000 | 0 | .001 | 0 | | |
| TOTALS | | 10.000 | 5.336 (Y) | 9.804 | 4.750 (X) | 11.810 | 4.921 (Z) |

Visual brightness (10 x Y) = 53.4%  $X + Y + Z = 15.007$

$$x = \frac{X}{X + Y + Z} = 0.317 \qquad y = \frac{Y}{X + Y + Z} = 0.356$$

$$X_w = X(.3101) \qquad Y_w = Y(.3163) \qquad Z_w = Z(.3736)$$

TABLE IV

Computation of Filter Colors

| Lens material | Appearance | Nearest Munsell color (1943) | Dominant spectral hue | Purity | X | Y |
|---|---|---|---|---|---|---|
| Cal. "C" - glass | green | 10GY8/2 | 559 | 13% | .317 | .356 |
| Cal. "D" - glass | green | 10GY5/3 | 562 | 22% | .327 | .379 |
| XN30 - plastic | yellow | 7.5Y6/1 | 573 | 15% | .333 | .347 |
| XN10 - plastic | neutral | NG3 | 500 | 1% | .312 | .315 |
| HN12 - plastic | blue | 10BG4/2 | 488 | 11% | .280 | .310 |
| TGm - gelatin | green | 2G6.3/8.5 | 536 | 27% | .282 | .440 |

TABLE V

Shifts of Low Saturation Colors by "Neutral" Sunglass Lenses, According to Revised (1943) Munsell Color Names

| Filter | | R | Y | G | B | P |
|---|---|---|---|---|---|---|
| No Filter | | 3R 4.98/3 | 5Y 5.15/1.5 | 7.5G 4.90/2.5 | 7.5B 4.92/3 | 5P 4.99/2.5 |
| XN 10 | NG3.5 | 10R 1.27/1 | 5Y 1.28/0.6 | 5G 1.23/1.5 | 10BG 1.27/1.3 | 5P 1.28/0.8 |
| XN 30 | 5Y6.11/1.3 | 5YR 2.92/2 | 5Y 3.03/2.2 | 8GY 2.85/2.5 | 10G 2.87/1.5 | 5R 2.92/0.6 |
| HN 12 | 10BG4.77/2 | 5RP 2.10/1 | 8.5GY 2.21/1.3 | 1.2BG 2.12/2.8 | 2.0B 2.14/2.5 | 2.5PB 2.14/1.5 |
| Cal. "C" | 8.5GY7.67/2.7 | 5GY 3.73/0.2 | 2Y 3.73/1.5 | 2GY 3.86/2.5 | 1.5G 3.71/2.6 | 1BG 3.73/3 |
| Cal. "D" | 7.5GY6.60/3.6 | 5YR 3.15/2 | 2.5GY 3.30/3 | 9GY 3.13/3.8 | 4G 3.15/3 | 5GY 3.16/1.2 |
| TGm | 2G6.34/8.5 | 7.5GY 2.93/4 | 8GY 3.12/5.5 | 1.5G 3.05/7 | 3G 3.26/7.2 | 2G 3.02/6.8 |

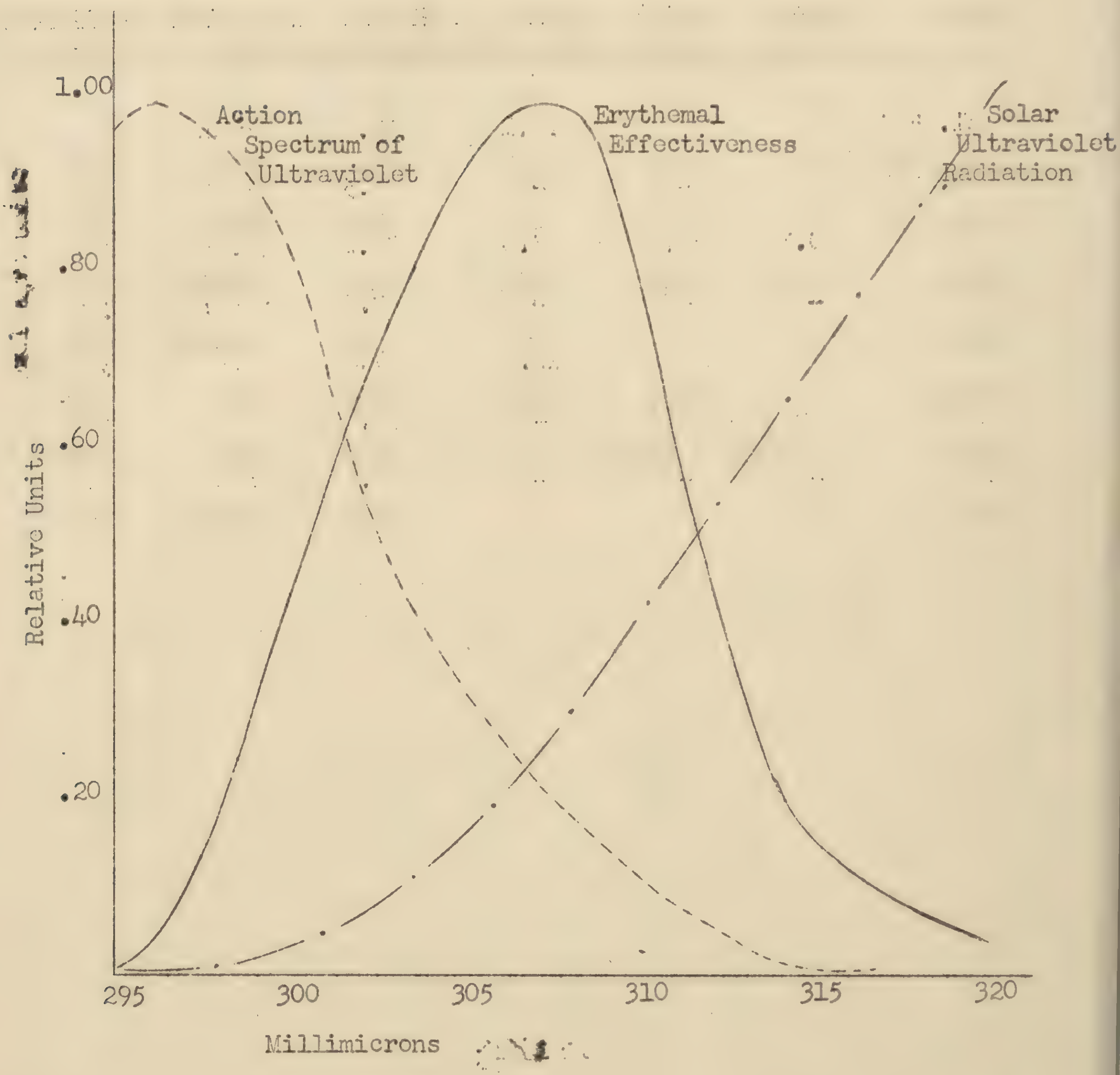
TABLE VI

Summary of Computations

| Lens | Ultra-violet | Total energy | Retinal intensity | Visual brightness | Apparent color | Acceptably neutral |
|---|---|---|---|---|---|---|
| | % | % | % | % | | |
| Cal. "C" | 0 | 29.8 | 14.1 | 53.4 | green | yes |
| Cal. "D" | - | - | - | 37.5 | green | no |
| XN30 | 0.3 | 39.0 | 5.6 | 31.4 | yellow | yes |
| XN10 | - | - | - | 8.2 | neutral | yes |
| HN12 | 0 | 38.1 | 12.1 | 17.8 | blue | yes |
| HN12 | (recent | sample) | - | 15.0 | blue | yes |
| TGm | - | - | - | 34.2 | green | no |

FIGURE I

Erythemal Effectiveness of Solar Ultraviolet Radiation



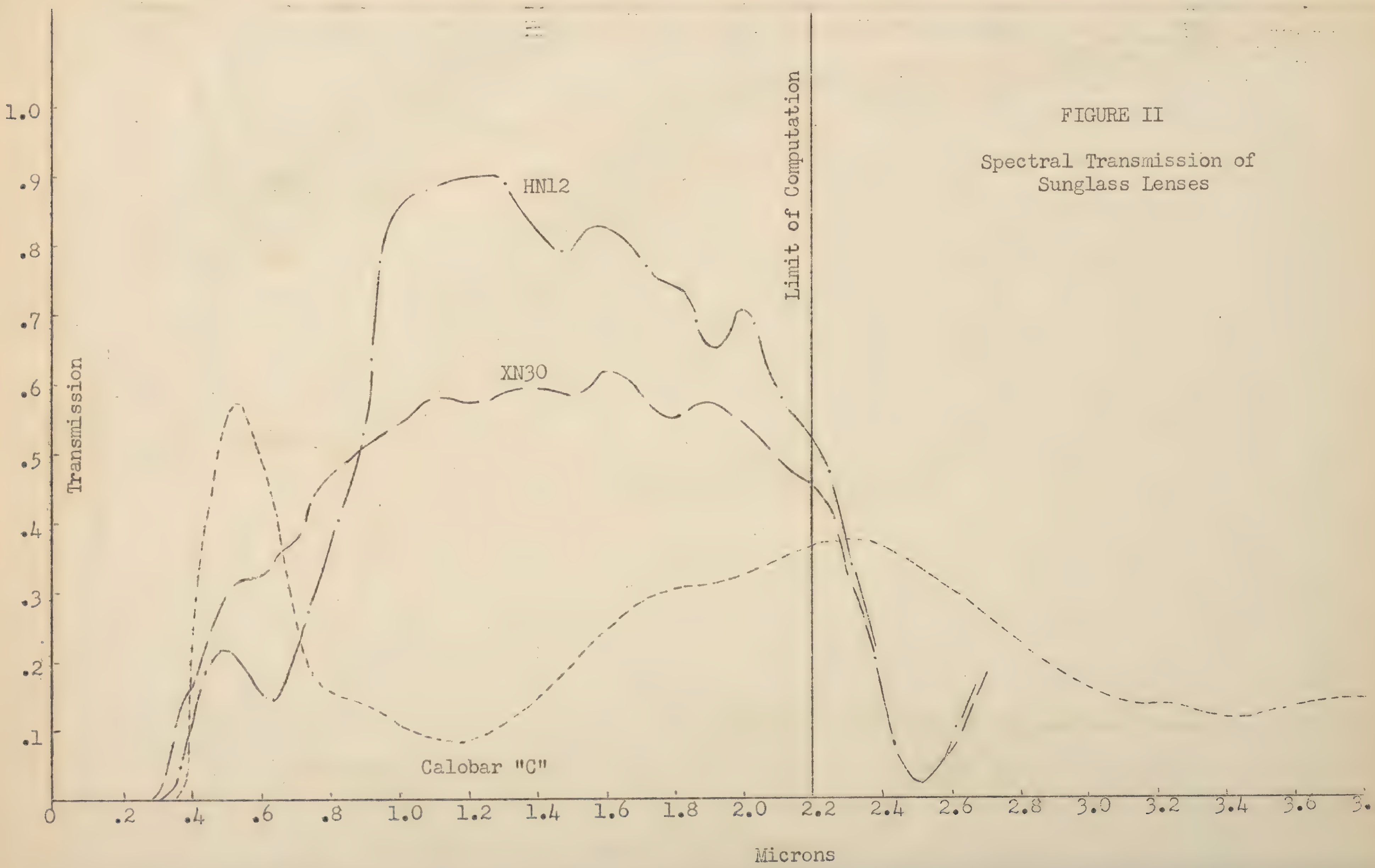



FIGURE II

Spectral Transmission of
Sunglass Lenses

FIGURE III

Solar Energy Transmission of Sunglass Lenses

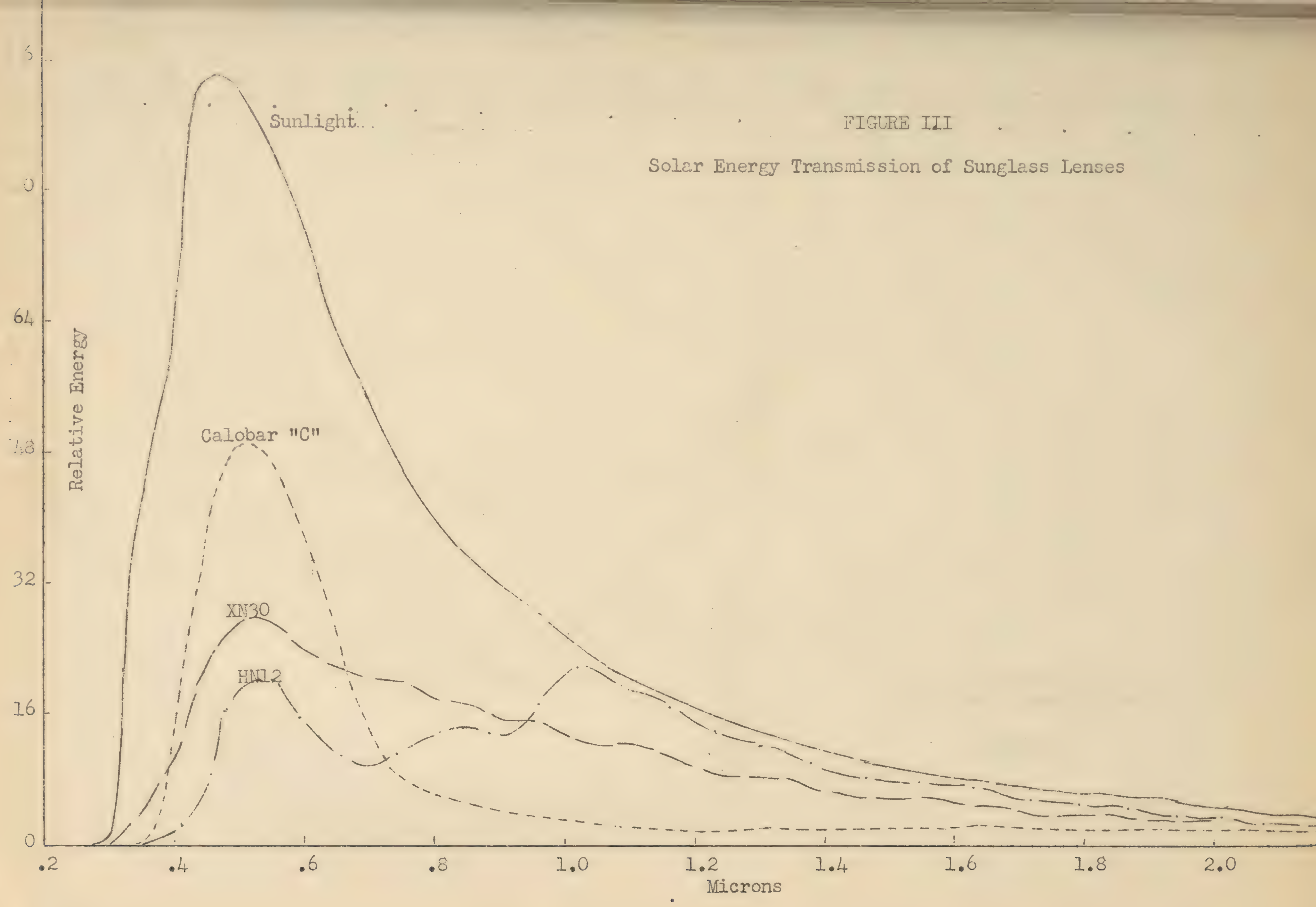


FIGURE IV

Energy of Retinal Images Through Sunglasses

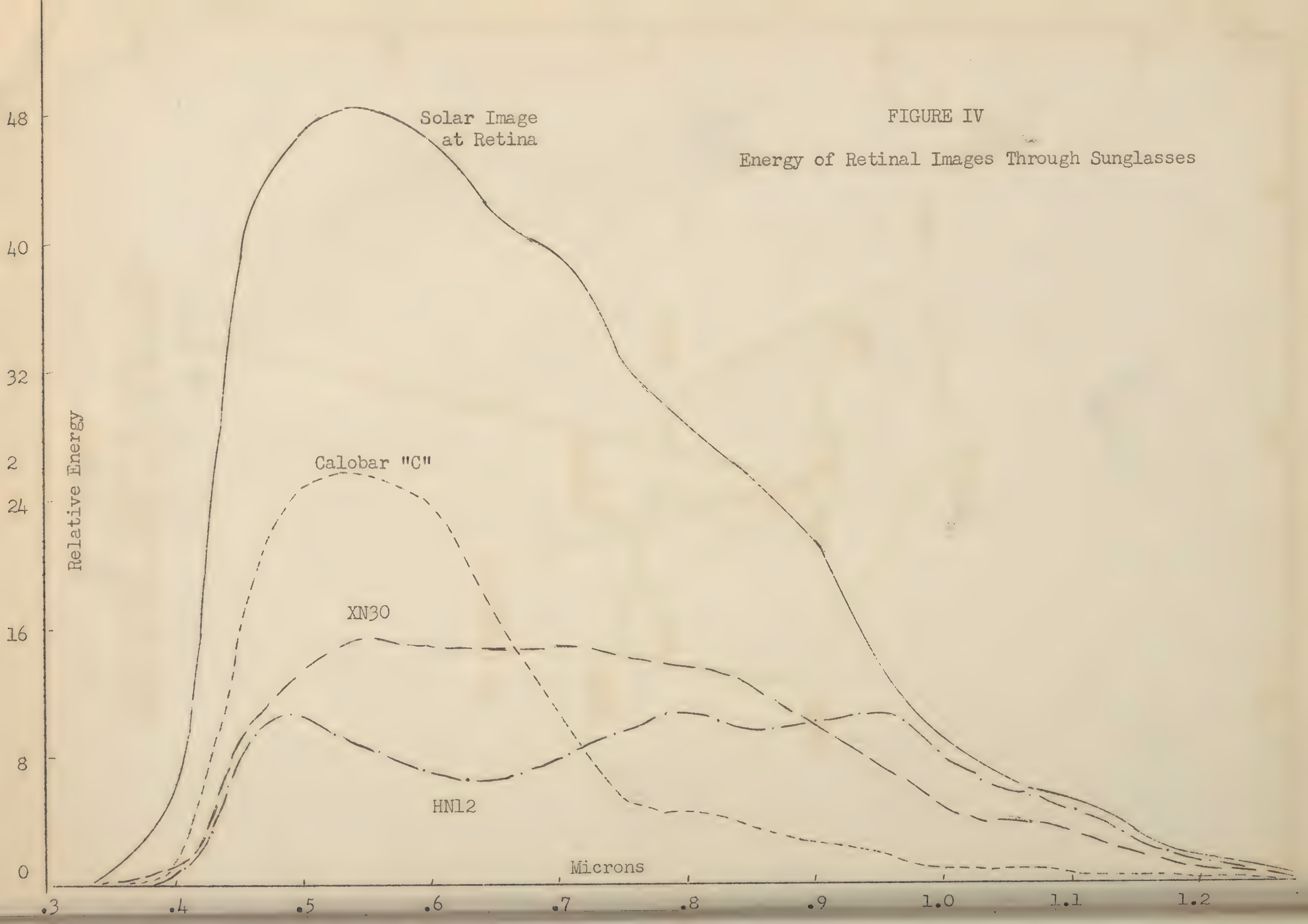


FIGURE V

Shift of "White" by "Neutral" Sunglass Lenses
According to I.C.I. 1931-Coordinate System

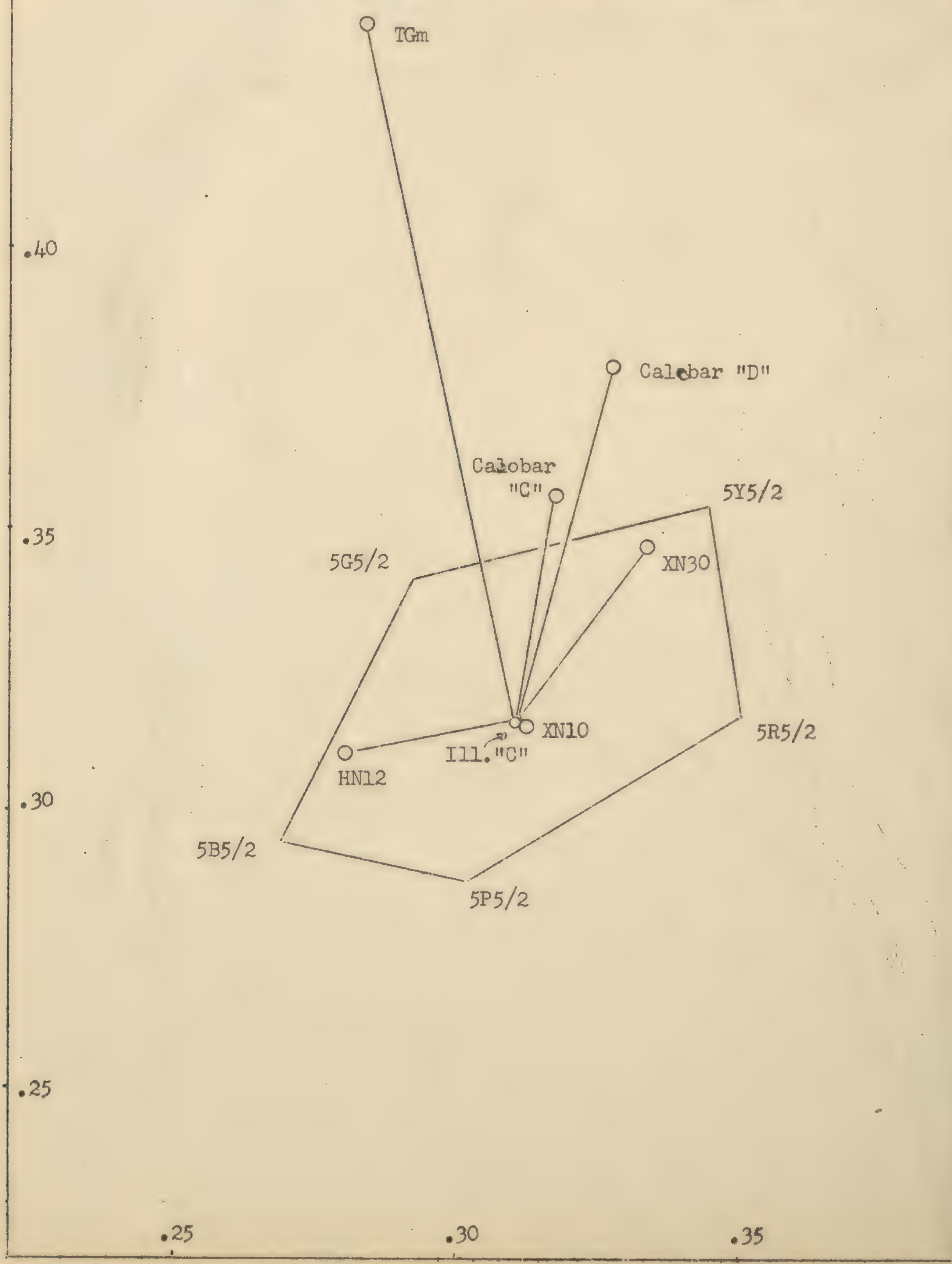
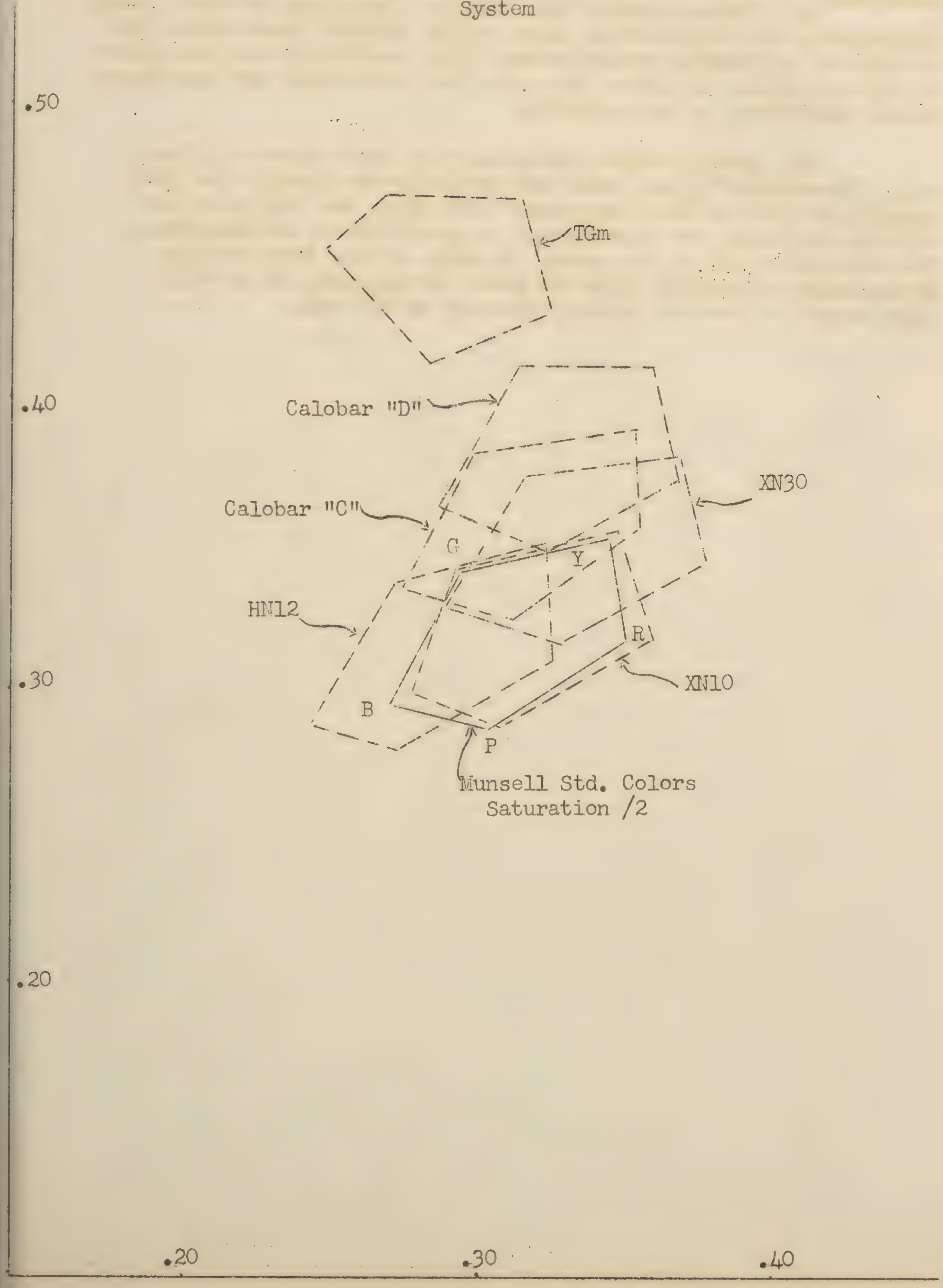


FIGURE VI

Shift of Low Saturation Colors by "Neutral"
Sunglass Lenses
According to I.C.I. 1931-Coordinate
System



Discussion:

Dr. O'Brien pointed out that the comparison of total energy transmission was made between glass of 58% visible transmission and plastic of 12% visible transmission. This would indicate that glass is superior since it offers five times the protection for equivalent visual absorption as does plastic.

Lt. Comdr. Peckham explained that other types of glass, e.g., "Rose-Smoke" glass, were not available for study. The most significant fact is that experience with glass has led to no bad effects, and since the plastic has no greater total transmission, the protection will be the same. In spite of the fact that the transmission of visible light is lower for plastic, it is still high enough to preclude looking directly at the sun.

## 5. VISIBILITY

### A. The Tiffany Foundation Vision Program

The following summary of the discussion was prepared by Professor Hardy.

The account of the vision program of the Tiffany Foundation was divided into two parts. Professor A. C. Hardy, Chief of the Camouflage Section of the NDRC, began by explaining the reasons for the establishment of the vision program at the Foundation. Because most camouflage is intended to deceive the human eye, accurate knowledge of the characteristics of vision is necessary for the proper evaluation of camouflage measures. In particular, data on visibility are needed over the entire range of brightness levels encountered during any type of military operation.

When the camouflage section of the NDRC first considered this problem, it was believed that the scientific literature already contained so much information on visual acuity and related topics that little experimental work would be necessary to bridge the remaining gaps and to produce a "Handbook on Visibility" that would be useful to all branches of the Armed Services. This assumption proved to be naive. The results obtained by the various investigators could not be fitted together, because these investigators had employed observers whose individual variations from a hypothetical mean were evidently considerable. Moreover, the observations were made with a great variety of targets, and there had been no agreement on the criterion of just noticeability. It became necessary, therefore, to obtain original data using a homogeneous group of observers and a standard criterion of just noticeability. Since there was need for speed in time of war, facilities for the mass production of visibility data were set up by the Tiffany Foundation. A theater was constructed in which ten observers can simultaneously view targets projected on a distant screen. These observers were carefully selected and were subjected to a training period before their observations were accepted. Only observers under twenty-five years of age were used, and, because young men in this age group are needed by the Armed Forces, the observing staff of the Tiffany Foundation was comprised of young women. As a basic specification, all observers were required to pass the eye examination given Navy lookouts.

Even using ten observers and rapid electrical methods of recording data, the task would have been unduly lengthy except for two important simplifying assumptions. A preliminary series of experiments showed that, except for excessively elongated targets, the visibility of a target depends only upon its projected area and is virtually independent of its shape. As a further simplification, it was assumed that brightness contrast is usually the important factor in determining visibility, the chromaticity contrasts playing a minor

role. Simultaneously with the inauguration of work at the Tiffany Foundation on achromatic contrasts, the Eastman Kodak Company began an investigation of the role played by chromaticity contrasts. The Eastman study verified the assumption that chromaticity contrasts are usually negligible in the presence of brightness contrasts. Nevertheless, circumstances are occasionally found when account must be taken of chromaticity differences, and the Eastman data provide a quantitative basis for the evaluation of such contrasts. The data obtained in both projects will be included in the proposed "Handbook of Visibility".

After the experimental facilities were set up at the Tiffany Foundation, a rapid preliminary survey was made of the visibility of targets both lighter and darker than their backgrounds. These data have been in existence for more than a year and have been used by the NDRC Camouflage Section in the solution of many camouflage problems. Perhaps the most striking lesson learned from the preliminary experiments was that the observer variability is not necessarily as great as is ordinarily assumed. For this reason, it was decided to repeat many of the experiments with greatly refined photometric techniques. Because the brightness levels covered by the experiments extended over a range of a billion-fold, many new photometric procedures had to be evolved. The resurvey of the visibility of targets lighter than their background has now been finished, and the results have been plotted for a variety of parameters. Work will proceed on the visibility of targets darker than their background.

Plans are being laid to produce the "Handbook of Visibility", which will include charts, tables, and worked examples enabling any officer, regardless of the amount of his technical background, to solve practical military problems concerning visibility. Two nomographic charts were exhibited as an illustration of the type of data presentation contemplated for this Handbook. In these charts the data on the visibility of targets brighter than their background was represented in such a form that the limiting range at which a target of any size becomes visible can quickly be found under any assumed conditions. As one example of the use of such a chart, the problem of the visibility of a light-lock on shipboard was discussed. The solution to this problem was expressed in terms of the highest brightness which the opening of the light-lock could have and still be invisible on a completely dark night under perfect atmospheric conditions. Professor Hardy emphasized that this example served well to illustrate a type of problem which can not readily be investigated directly because conditions outdoors at night are difficult to ascertain with certainty. Hence, any answer reached by direct experimentation would always be subject to doubt. Although in the light-lock problem, completely clear air is a proper assumption, the effect of the atmosphere must, in general be taken into account. It is intended that the "Handbook of Visibility" will contain data and charts that will enable this to be done; the experimental work that

has been done by the Tiffany Foundation toward this end was discussed by Dr. S. Q. Duntley, Technical Aide to NDRC Section 16.3.

Dr. Duntley began his discussion by pointing out that all distant objects are viewed through a veil of atmospheric haze which obliterates detail and reduces contrast to such an extent that large objects often become invisible at much shorter ranges than would otherwise be predicted. This subject falls naturally into two categories, depending upon whether the line of sight is along a horizontal path or along a more nearly vertical path. The Tiffany Foundation, under its contract with OSRD, has been asked to investigate the role played by atmospheric scattering in the reduction of visibility along both vertical and horizontal paths. Because very different experimental procedures have been adopted for these two investigations, they have been undertaken by separate research groups, and their work was discussed as separate problems.

## I. The Visibility of Objects Viewed Along a Horizontal Path

Within the atmostphere two processes are continually taking place: (1) light reflected by any object is attenuated by atmospheric scattering as the light traverses a horizontal path; (2) daylight is scattered toward the observer throughout all the space along the line of sight.

The appearance of a distant object is governed by the balance between the transmitted fraction of the light originally reflected from the target and the space-light contributed by the intervening air. An insight into the relation between these two components can be gained by noting that an object whose brightness matches that of the horizon does not appear to change brightness with distance. The atmosphere may therefore be considered to be in optical equilibrium, in the sense that each unit of volume along the line of sight contributes an amount of space light exactly equal to the quantity of the transmitted light that it attenuates.

A mathematical formulation based upon this reasoning and involving a generalized atmospheric attenuation coefficient was presented. A nomographic chart based on the theory was exhibited, and this was shown to eliminate the need for computation in the solution of visibility problems. In order to test the validity of the equation, the Tiffany Foundation has set up on the shores of Cold Spring Harbor large black and white billboard-type targets at ranges up to 6000 yards. A high precision A. C. telephotometer has been built to measure the apparent brightness of these targets. Preliminary data in support of the theory were shown, and plans were described for the collection of further data. Complete meteorological records will be kept for purposes of correlation. Values of the atmospheric attenuation coefficient derived from transmission measurements are secured by means of a Transmissometer loaned to the Foundation by the National Bureau of Standards. A numerical

example was used to illustrate a procedure for including a correction for atmospheric scattering when the range of visibility of small targets is predicted from the visibility data.

## II. The Visibility of Objects Viewed Along a Vertical Path

Stratification of the atmosphere, both in the nature of the scattering particles and in their number per unit volume, causes the screening properties of the atmosphere along vertical paths to differ from those found along horizontal paths. The theory of vertical visibility is not yet as highly developed as is the theory of the horizontal case; this lack of development is due in part to the paucity of experimental data. Nearly all of the hitherto available information on vertical visibility was published by the Germans in 1940. The experiments they described were conducted with an aerial camera converted by means of a prism into a spectrograph capable of analyzing visible radiation reaching an aircraft in flight. Although the apparatus was makeshift and the precision of the results was low, useful information regarding the reflectivity of natural terrains and the screening properties of the atmosphere was obtained on two clear mid-summer days in the vicinity of Berlin. These fragmentary data, after theoretical extrapolation, have been used inconnection with a number of problems of vertical visibility and aircraft camouflage.

To secure more extensive and more accurate data of this type, the Eastman Kodak Company, under contract with OSRD, designed, built, and delivered to the Tiffany Foundation a photographic aerial spectrophotometer, which has been called a Spectrogeograph. During the spring of 1944, the Tiffany Foundation sent a field expedition to Florida where, at the request of the Corps of Engineers, the Army Air Forces placed a B-17 at the Foundation's disposal for several weeks. During this period, the spectrogeograph was used to investigate a number of problems, including the screening properties of the atmosphere along vertical paths. Complete meteorological records were kept by an observer assigned to the expedition by the U. S. Weather Bureau. The visibility data secured may thus be related directly to the statistical weather summaries for foreign theaters prepared by the Bureau for the strategic planning boards. The work of reducing these spectrograms has been delayed by the pressure of more urgent projects, but preliminary data for one particular day were exhibited. It is anticipated that the "Handbook of Visibility" will contain nomographic charts based upon the data secured with the spectrogeograph in Florida, and that these charts will permit the visibility of objects viewed from aloft to be predicted.

Discussion:

Dr. Bronk asked how these data could be applied to the problem of painting upper wing surfaces. Dr. Duntley explained that similar German data have been used by the AAF for this purpose; the reflectance of various terrains at various altitudes is measured, and the wing surfaces are painted accordingly.

Since threhold values represent a probablity of seeing an object 50% more than chance, Lt. Comdr. Peckham wanted to know if that means that in a practical field situation half of the observers will see it. Dr. Hardy said that a correction can be made for any probability of seeing desired. These data will be used chiefly in relative fashion and a standard is needed.

Mr. Harrison was interested in the possibility of correlating the horizontal and vertical scattering of light so that measurements can be made on the ground. Dr. Duntley didn't think this would be possible because of the stratification of the atmosphere. Experimentation on this point is being carried out using the visibility of the sun as an index of vertical scattering.

Dr. O'Brien wondered if in the calculations of scatter in the horizontal plane any assumptions had been made about the direction of scatter. Dr. Duntley said that no assumptions had been made except that no scattered light returns to the beam.

Mr. Douglas stated that he knew of no evidence to support the assumption of the constant .02 for daylight acuity. Dr. Hardy pointed out that the value checks with their best research observations although in practical field observations the value is higher, because targets not seen are not counted in results.

B. Problems of Visibility - Bureau of Aeronautics

Lt. Comdr. David F. Leavitt, USNR

The visibility problems of the Equipment and Materials Branch of the Bureau of Aeronautics include those of aircraft camouflage, identification markings, glare reducing compounds, paints, transparent plastics, and visual aids to sea rescue.

The three low visibility paint schemes currently in use on Naval aircraft are known as the Basic Sea-blue Non-specular Scheme and the Anti-submarine Warfare Schemes I and II. Colored plates of the three schemes were distributed at the meeting. The Basic Scheme is a compromise to provide the maximum concealment against aky and sea backgrounds. A.S.W. Schemes I and II provide sky camouflage only and are designed for predominant clear and predominant overcast conditions respectively. The diffuse reflectance factors of the paints in the Basic Scheme are 4.5% topside, 15% sides

and vertical surfaces, and 75% white on the bottom surfaces. The top and sides of A.S.W. Scheme I are 26% and 47% reflectance, with glossy white on the under surface. In Scheme II the 47% gray of the sides is replaced with non-specular white. All paints are non-specular with the exception of the white described above, and the topside of horizontal airfoils in the Basic Scheme, which is a semi-gloss of a degree of specularity approximating that of the surface of the sea. The colors used in these schemes are neutrals and near neutrals and are gradually blended one into the other. Areas of fuselage beneath the horizontal airfoils are lightened to soften cast shadows. The Navy has recently adopted an overall glossy Sea-blue paint treatment for all carrier-based airplanes. This move gives up all attempts at sky camouflage while retaining, to a large degree, concealment against the sea. This was expected to give increased aerodynamic efficiency, simplification of application and maintenance, and better concealment under searchlight than the Basic Scheme.

The Bureau of Aeronautics is at present conducting an extensive visibility program at the Naval Air Station, Patuxent River, Maryland, to determine the visual threholds of all types of Naval aircraft as seen against the sky. We are using models of scale 1 to 72. The visual threshold of camouflaged aircraft within 60 degrees on either side of the sun may be as much as 3 times that of the lowest visibility position when viewed down-sun. A polar curve of visual thresholds, plotted around the observer position at the center, will approximate a circle when the sky is overcast or when the sun is at the zenith. When the sun's altitude is less than 90 degrees, the curve assumes an elliptical shape. The white plane, A.S.W. Scheme II, in a low sun, provides a narrow ellipse with the long radii up-sun (darker than the background) nearly equalled by those down-sun (lighter than the sky). The shortest radii are in the region of cross-sun. The curve for the Basic Scheme is wide with the short radii nearly directly down-sun or the 6 o'clock position when the sun is at 12 o'clock. Scheme I, or the gray plane, has the shortest radii approximately half-way between the cross-sun and the down-sun position or the 4:30 o'clock and 7:30 o'clock positions.

NDRC Section 16.3, under Dr. Hardy, is cooperating in this program. They have loaned the Navy two of their trained observers, and on completion of the program which Dr. Hardy described, aid will be given by NDRC in extrapolating data applicable to all levels of natural illumination.

The model threshold tests are being conducted on Chesapeake Bay. The models are rigged on frames at Cedar Point Light House Island. The obervers approach the island from the desired direction with respect to the sun. When an observer sights a model, the boat is stopped, and a signal is given. Personnel at the light house take the range of the boat. Data are taken on the

illumination, sky background brightness, and the attenuation of the atmosphere.

Threshold comparisons are being made with standard visibility targets. Comparisons of model thesholds with those of similar type actual aircraft in flight are scheduled at certain intervals of the test program. Airplanes are observed flown to the extinction point against the same sky background and along the same line of sight as the model. It is expected that valuable data influencing concealment tactics will be obtained from this program.

Other visibility problems in which aid has been requested of the Camouflage Section of the Bureau of Aeronautics are those of emergency sea rescue aids. An attempt will be made to measure the thresholds under various levels of illumination of rubber boats, dye markers, metallic slicks, mirror flashes, smoke signals, and pyrotechnics as seen from the air. Painted markings and lights as aids to recognition, rendezvous, and night formation flying are problems of providing visibility at close range without the security hazard of increasing materially the distance at which the airplane may be detected by the enemy.

In spite of the great advance of radar, the human inclination to disbelieve evidence other than visual still exists and the expression "seeing is believing" holds good in many cases of surprise attack. Reports of our recent carrier-based plane attacks on the Japanese fleet have stated that although it is reasonably certain that the Jap had radar warning of the imminence of attack, his evasion maneuvers were not started until after visual contact.

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Discussion:

Lt. Comdr. West asked about the possibility of using the Tiffany Foundation facilities for determining the visibility of various targets and signals in sea rescue. He pointed out that research is needed on the relative density and duration of smoke signals necessary for a high sighting probability at various ranges.

Dr. Hardy indicated that the visibility factors in the air-sea rescue problem could be handled, but that sea search is complicated by other than visibility factors. A dye signal, for example, which is intended to be visible to friendly planes cannot be rolled up and put away when enemy planes pass over.

D. Problems of Visibility - Army Ground Forces

The following list of some of the visibility problems which confront ground force units was provided for inclusion in the Proceedings by Headquarters, Army Ground Forces.

1. Vehicular movements by day or night under conditions of fog, haze, dust, and total blackout.

2. Passage and marking of minefields at night.

3. Marking front lines by day and at night.

4. Marking dropping zones for supply by air.

5. Identification of friendly aircraft by day and at night.

6. Dawn and dusk observation, both air and ground.

7. Night observation, air and ground.

8. Day or night observation under conditions of glare, haze, dust, or fog, both air and ground.

9. Development of a simple, practical, and efficient night vision tester.

10. Development of optical instruments with great light gathering qualities.

11. Design of graduations on all sights and sighting equipment with a view to obtaining simple, clear-cut graduations which are easy and positive to set and which facilitate the elimination of involuntary errors.

12. Investigation of all means and methods of locating targets at night, such as machine guns, automatic weapons, anti-tank guns, etc.

13. Selection and training of personnel for night operations.

6. NEW MODEL 6x42 PLASTIC BINOCULAR

The following report was presented by Lt. (jg) F. O. Ottie.

A new plastic binocular, meeting the rigid requirements of military use, recently has made its appearance in a combat binocular, designed and developed by the U. S. Naval Observatory. Extensive tests have shown the combat binocular to have the characteristics demanded in a special-purpose binocular, particularly for severe service conditions where ordinary general-purpose binoculars fail to stand up.

The instrument was designed as a 6x42 binocular, but it may readily be converted to a 7x50, the conventional binocular for Navy use. The revolutionary features of the combat binocular include extreme resistance to fungus growth, resistance to the corrosive effects of salt water and air, effective waterproofness when submerged to depths of over 100 feet, sturdy mechanical construction, and fixed adjustment of focusing and interpupillary distance settings. These characteristics make the instrument exceptionally well suited to the severe conditions encountered in the tropics, front-line fighting, amphibious operations, small craft, and submarines.

The development of a plastic binocular was originally initiated under the stress of the aluminum shortage in an effort to provide a satisfactory substitute material for binocular bodies and release the large quantities of primary aluminum used in binocular production. The new plastic material which resulted from this development was found not only to provide a satisfactory replacement for aluminum, but also to possess advantageous characteristics of its own, which assure plastics a permanent place in the manufacture of optical instruments.

The many problems encountered in the selection of a suitable plastic material and the design of the binocular were solved by the Naval Observatory, in close collaboration with the National Bureau of Standards, the Society of the Plastics Industry, and individual plastics and optical manufacturers. No commercially available plastic material contained all of the properties required for use in binocular bodies. It was necessary to develop a plastic formulation which would keep its dimensional stability over long periods of exposure to tropical and arctic conditions. Distortion and misalignment of the optical systems could not be permitted. High impact strength plastic material was needed to provide for serviceability.

The material developed not only fulfills these requirements but exceeds them in its performance. The plastic binocular is capable of withstanding far more shock than an aluminum binocular. The resistance of the plastic material to the penetration of

moisture and fungus provides addtional important advantages which have become increasingly apparent with the extension of military operations into zones of wet and inclement weather.

The molded plastic body and the simplified design of the combat binocular make the instrument ideally adapted to mass production. Fitted with a sturdy and serviceable plastic carrying case, the combat binocular, by virtue of its characteristics, finds extensive application as a special-purpose military instrument.

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Discussion:

Members expressed some doubt about the usefulness of a binocular with a fixed IPD. Dr. Wedell, citing British experience, called attention to the importance of the correct setting for each individual. Lt. Ottie stated that only 13% of the service population have IPD's outside the ranges covered by the three fixed settings -- 62, 65, 68. These men would have to be furnished adjustable binoculars.

Lt. Dyson reported that the binocular had been exhibited to officers at CNO who indicated a preference for the standard 7x50 binocular. Lt. Ottie thought the reason might be that older men cannot accommodate enough to clear the field. He said that when compared to other binoculars, the new model has as good optical construction as any, and it is a more durable instrument, good for jungle fighting, amphibious landings, etc.

Samples of the binocular for examination may be obtained from Comdr. Brandon, U. S. Naval Observatory.

# ABSTRACTS

## 1. GOGGLES FOR ANTI-AIRCRAFT LOOKOUTS IN THE SUN SECTOR

Briggs, G. H., and Giovanelli, R. G., Australian Scientific Liaison Office, Australian Technical Paper No. 804, March, 1943, 4pp., (confidential).

A goggle which eliminates the glare of the sun and the sky and the danger of damage to the retina has been designed for use by anti-aircraft lookouts for scanning in the neighborhood of the sun. It is constructed with composite lenses of two different kinds of absorbing glass; a small disc immediately in front of the eye pupil, having a very low visual transmission, is attached to a full-sized welders' lens of 2 to 14% visual transmission. The dense discs are reduced by the absorption of the glass to about $2 \times 10^{-6}$ their original intensity. The spotter searches the sky through the lighter glass, and, when necessary, looks through the disc at the sun, which he sees at a brightness about the same as that of the normal sky. Tranmissions of visible, infrared and ultraviolet light are given for the four types of glass used in these goggles. Adjustment at the nose bridge, or rotation of the lens in its mount (the small discs are mounted eccentrically) provides for alteration of the interpupillary distance.

## 2. THE EFFECTS OF PAREDRINE ON NIGHT VISION TEST PERFORMANCE

Verplank, W. S., Medical Research Laboratory, U. S. Submarine Base, New London, 25 May 1944, 12pp., (confidential).

Dilating the pupils by administering paredrine results in a statistically significant improvement in performance on adaptometer tests. In an experiment with seventeen subjects, highly trained in use of the eyes at night and with known standards of performance and variability on adaptometer tests, paredrine was given on the second of four days of testing. Results obtained on the NDRC Model III Adaptometer at three brightness levels (3.90, 3.75, and 3.60 log μμ l) show an improvement on the second (paredrine) day. This improvement is approximately equivalent to that which would be produced by an increase in brightness of .07 log units. Since similar improvements had on occasion appeared in previous data on these subjects, but not in association with the use of the drug, a second experiment

was planned. One hundred and twenty-four inexperienced subjects were tested on the Navy Radium Plaque Adaptometer. Half the group received the drug on the first experimental day, and half, the second. For these subjects performance under the effects of paredrine improved approximately as it would if the brightness of the plaque were increased by .20 log units. This improvement is about equivalent in amount to the improvement in second day scores over first day scores.

## 3. ULTRAVIOLET AUTOCOLLIMATING REFLECTOR UNITS

Technical Staff, Engineer Board, Report No. 819, 24 May 1944, 35pp., (confidential).

An effective blackout driving system employing an optical device to convert incident ultraviolet radiation to a narrow band of visible light has been tested and demonstrated. The ultraviolet sources, mounted on the vehicle near the line of sight of the driver, activate the fluorescent phosphor in the autocollimating reflector units used to mark the roadway, signs, or other vehicles. These units have a concave, aspherical surface to obtain retrodirective reflection. Tests conducted at Camp Lee, comparing this system with standard blackout driving equipment, indicate that although the use of ultraviolet radiation was demonstrated to be possible and the units meet specified military requirements, it is of doubtful practical value in spite of its advantage of affording greater security from visual detection. The disadvantages of the ultraviolet system are: (1) the absence of illumination which prevents the vehicle operator from seeing the roadway, and (2) the large amount of special equipment required.

## 4. CENTRAL AND PARACENTRAL VISUAL ACUITY AT DIFFERENT LEVELS OF ILLUMINATION

Mandelbaum, J., and Rowland, L. S., School of Aviation Medicine, Randolph Field, Project No. 220, Report No. 1, 23 June 1944, 3pp., (open).

Since visual acuity decreases rapidly from fovea to peripheral retina, and since the dark adapted fovea has a relatively high light threshold which decreases progressively out to 20° in the periphery, there should be some intermediate region where these opposing factors are balanced and form discrimination is maximum for night illuminations. To determine the range of illumination for which paracentral vision gives higher acuity than central and to determine the maximum acuity at these intensities, an intensive study of the eye of a single individual

was made. The size of the test target (black Landolt ring), projected on a white screen, could be varied continuously from 12.5 mm. to 245 mm. The background brightness was varied from 9.04 log μμ l to 4.3 log μμ l in steps of 0.3 log unit. Direction of fixation in peripheral measurements was controlled by means of a movable red fixation light illuminated for 1/5 second. Several presentations were made of each size test object at each level of intensity. The minimum visual angle at which 3/4 of the presentations were correctly recognized was determined for each intensity. Conclusions: (a) Paracentral acuity exceeds that at the fovea when the intensity is 6.3 log μμ l or lower, and (b) in this range of intensities, visual acuity is highest in the temporalretina about 4° from the fovea. Similar measurements for a number of individuals are planned.

## 5. STUDY OF REQUIREMENTS FOR EXTERIOR LIGHTS FOR CARRIER BASED AIRCRAFT

Andrews, Lt. C. C., United States Naval Air Station, Patuxent River, Project No. TED No. PTR - 31A39, 18 August 1944, 5pp., (confidential).

Night rendezvous, using the present standard exterior lights, is one of the most difficult operations performed by carrier based aircraft. Several schemes of lighting have been tested in actual night rendezvous to determine the most satisfactory light arrangement for both recognition and joining up. Night rendezvous is greatly facilitated by the use of a shielded light so mounted as to flood the side of the fuselage and yet not cause glare to the pilots of the lead or closing airplane. Red light may be desired by some squadrons as a protection to night adaptation of pilots' vision. Red bulbs illuminate the fuselage sufficiently for the primary purpose, but with red light it is more difficult to distinguish an identifying figure painted on the side of the fuselage. However, since the light is indirect, the effect of white light on night adaptation is thought to be of little consequence. Therefore a white light is recommended. Identification of an individual airplane at moderate range is made possible by painting a number or a letter within the area flooded by the light. Identification by squadrons or groups can be accomplished by turtle-back lights of different colors. Switches for all external lights should have bright and dim positions. Standard recognition lights are of doubtful value.

6. THE EFFECT OF EXPOSURE TO ULTRAVIOLET AND INFRARED RADIATION ON THE RATE OF DARKNESS ADAPTATION

Langstroth, G. O., et al., Physics Department, University of Manitoba, 11 January 1944, 5pp., (secret).

In the search for an effective method to increase the rate of dark adaptation, another possibility has been eliminated. Neither pre-exposure to ultraviolet nor concurrent exposure to infrared radiation decreased the adaptation period under the conditions of this experiment.

7. THE MEASUREMENT OF IMPROVEMENT IN "NIGHT VISION" AS A RESULT OF TRAINING

Hill, A. Bradford, and Williams, G. O., Flying Personnel Research Committee Report No. 568, 1944, 22pp., (secret).

Night vision was tested by a newly devised procedure in which subjects report the orientation of airplane silhouettes of various sizes viewed from a distance of 17 feet against a green background (reflectance not given) under an illumination of .0005 f. c. (approaching starlight level). The correlation coefficient between the scores on two tests given to 57 inexperienced subjects and separated by three days was nearly 0.9, indicating a satisfactory reliability. Another group of 30 subjects undergoing a course of night vision training was tested immediately before and immediately after its training. As a standard of comparison a group of 43 subjects on the same station, not being trained, was twice tested with the same interval of time between its tests. Neither the trained nor untrained group showed any improvement in its average standard of performance. (It is assumed that the effects of night vision training, while not apparent in threshold measurements under controlled artificial test conditions, might be demonstrated in more practical field tests.)

8. STUDIES AND INVESTIGATIONS IN CONNECTION WITH A TEST FOR PERIPHERAL VISUAL ACUITY: TECHNIQUES APPLIED TO NIGHT VISION; RESULTS OF EARLY EXPERIMENTS

Low, Frank N., Committee on Aviation Medicine Report No. 332; May, 1944, 3pp., (open).

Visual acuity was measured with Landolt circle test objects of different separations at several points in the peripheral retina under constant scotopic illumination. Two subjects were given 11 successive tests to check the amenability of night

vision to improvement. One more than doubled his original efficiency and the other improved about 50%. A comparison of results on this test to those for 100 subjects tested for day vision show that simple form acuity is somewhat poorer for night vision than for day vision and that the potentiality for improvement seems to be less for night vision than for day vision.

## 9. USE OF TETRAHEDRAL PRISM IN SURVEY

School of Artillery, Larkhill, England, Military Attache Report No. 68562, May, 1944, 1p., (restricted).

Any ray of light impinging on the base of a tetrahedral prism (a triangular pyramid with an equilateral triangle as a base and three similar isosceles triangles as sides) is reflected from all three internal surfaces and returns upon itself. British experimentation with such a prism for night survey demonstrates that it can be clearly seen through a telescope when a light is trained on the prism from the sighting instrument.

## 10. PHOTO FLASH SPOTTING

School of Artillery, Larkhill, England, Military Attache Report No. 68591, 16 May 1944, 4pp., (confidential).

The difficulties in obtaining accurate bearing to a flash of a firing artillery weapon, especially at night when there are no visible landmarks, may possibly be surmounted by the use of cameras. Experimentation has been done with an F24 (5" focal length lens) camera, modified so that film can be driven past the lens vertically and continuously at about 1/4" per minute, rolled into a light-proof, removable box, and processed immediately. A lamp, fixed inside the camera and lighted at the time of flash, registers on the edge of the film. Flash observation posts are selected; cameras are set up at the OP stakes and aimed properly on a sector. An orienting lamp, mounted on a pole, is placed about 100 yards from the OP at a carefully measured azimuth. Controlled by a commercial timing device, this lamp makes a broken line of known direction on the film, the breaks indicating intervals of one minute. When photo observations are desired, the film driving motors are started and the orientation lights are turned on. All internal camera lamps are wired so that a flash recorded at any of the observation posts is registered on all films. Exposed films are examined for the same gun flash; the distance from the orientation trace to the gun flash is measured; and the azimuth of the gun flash is calculated with an accuracy of within five minutes of arc. Greater accuracy is possible with this instrument and no insurmountable technical difficulties are anticipated.